

Shipboard Tests of the SeaCURE (Siemens)

Ballast Water Management System
(Filtration and electrochlorination)
for Type Approval according to Regulation D-2
and the relevant IMO Guideline (G8)

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Final report of the shipboard tests of the SeaCURE (Siemens)
Ballast Water Management System (Filtration and electrochlorination)
for Type Approval according to Regulation D-2 and the relevant IMO Guideline (G8)

(October 2012 - May 2013)

Shipboard tests on board MV COSCO Fortune

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S. Gollasch 12-07-2013

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1. Introduction

The SeaCURE¹ ballast water management system consisting of filtration and electrochlorination was developed by Siemens Water Technologies LLC²., Union, NJ 07083, USA.

The four shipboard test cycles to test the performance of the SeaCURE system were undertaken on two voyages of the container vessel MV COSCO Fortune between October 2012 and May 2013. The vessel particulars and the dimensions of the test tanks (the control and treated tanks) are shown in Table 1 and Figure 1. For the location of the test tanks see Figure 2.

Table 1. Main dimensions of the test vessel and tank details.

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Vessel name	COSCO Fortune
IMO number	9472127
Flag	Hong Kong
Class	LR
Vessel type	Container (13114 TEU)
Length overall	366.45 m
Gross Tonnage	145534 t
Total ballast water capacity	36013 m ³
Number of ballast tanks	26
Number of ballast pumps	2
Capacity of ballast pump	1500 m ³ /h (for each pump)
Number of ballast water	1
treatment systems installed	
Treatment system capacity	1500 m ³ /h
Control tank	Different tanks, including double bottom
	WBT, PS and side wing WBT, PS
Treated tank	Different tanks, including double bottom
	WBT, SB and side wing WBT, SB

The test ship is only since April 2012 in service and calls regularly for several ports in Europe (including Rotterdam, Felixstowe, Hamburg and Antwerp) and Asia (including several Chinese ports e.g. Dalian and Hong Kong and also calling at Singapore).

The BWTS installed on board MV *COSCO Fortune* has a treatment rated capacity to treat 1500 m³/h. The treatment system was installed in 2012, and it is fully implemented and integrated into the ballast system of the vessel.

¹ This ballast water treatment system was formerly named SiCURE.

² Formerly Siemens Industry, Inc.

With the exception of test cycle three, during all G8 test cycles both the control tank and the treated ballast tanks, were filled and emptied as much as possible and this was conducted sequentially. Test cycle three was different as during ballast water uptake, both the treated and control tank could only be filled to 85% of their capacity due to the cargo situation. For the same reason the discharge could not be done as planned in the Port of Hamburg, but was conducted when the vessel was in the North Sea near the entrance to the Elbe River. Due to weather conditions and not to impair the ships stability, it was only possible to discharge ca. 50% of the control tank, but the treated tank was discharged until suction was lost as in all other test cycles.

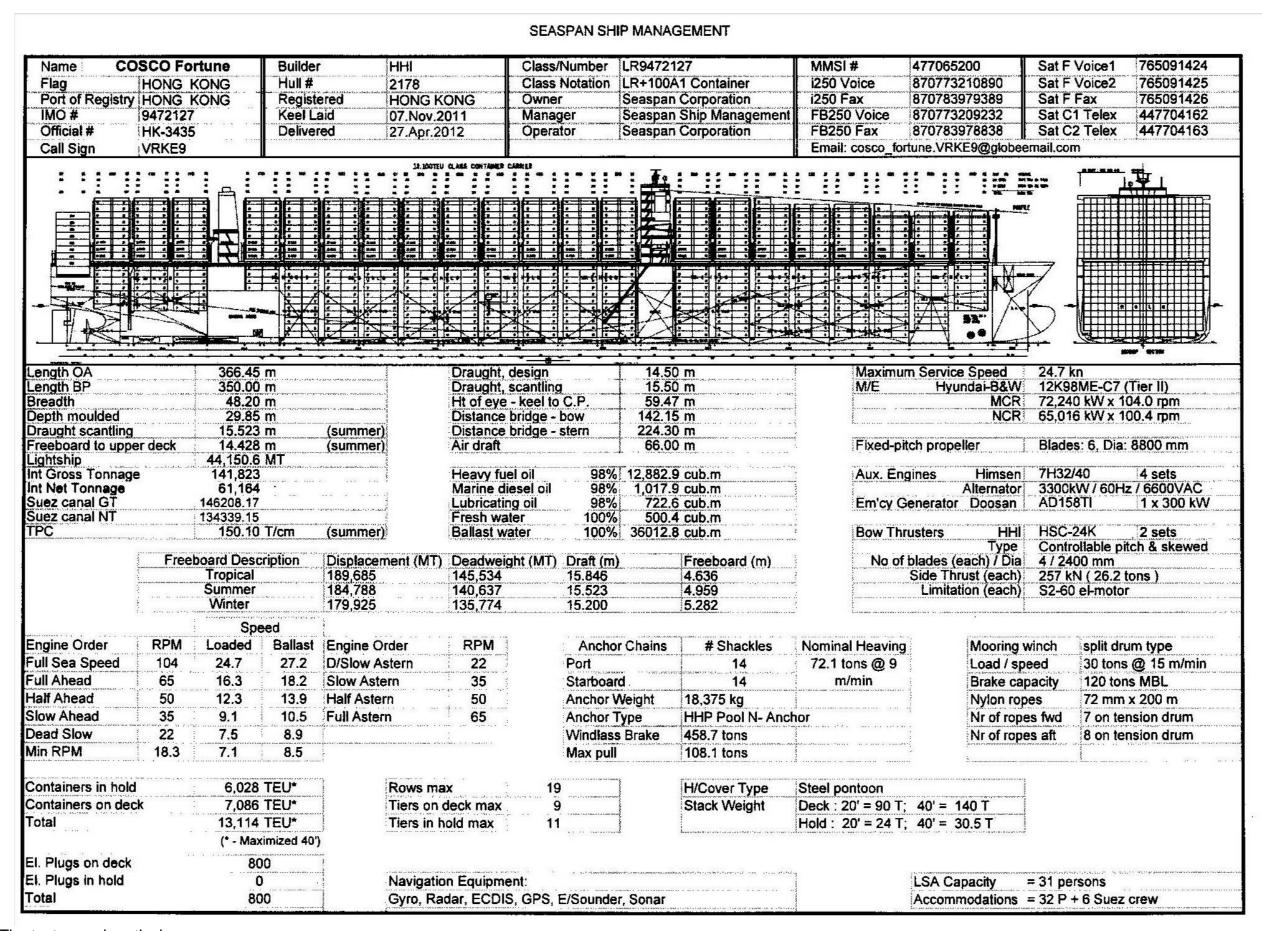


Figure 1. The test vessel particulars.

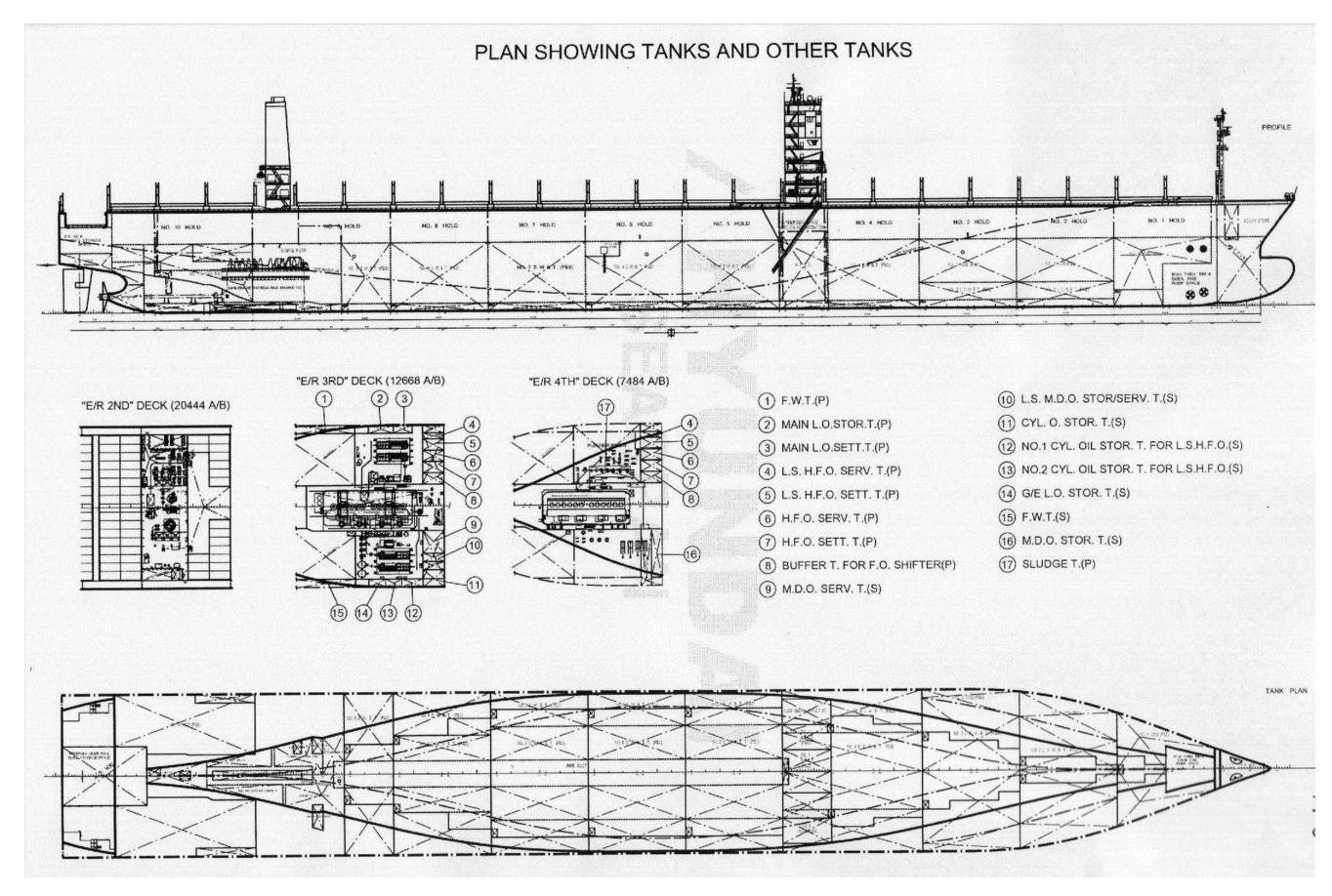


Figure 2 Tank plan of the test vessel MV COSCO Fortune. The double bottom water ballast tanks 3 or the side wing water ballast tanks 6 were used for the tests with the port side tanks used for the control experiment and the starboard tanks for the treated water tests.

All samples were taken during the entire ballast water uptake and discharge time, i.e. during the entire pumping event in accordance with the test plan (Gollasch 2012). This approach results in a more accurate organism density measurement compared to taking sequential sub-samples during only parts of the ballast water pumping operation (e.g. in the beginning, middle and end of the pumping time), because, when taking sequential samples, organism rich water layers may be missed during the sampling event.

The ballast water was taken up in the following regions:

- Test cycle 1, uptake Felixstowe, United Kingdom, discharge Hamburg, Germany;
- Test cycle 2, uptake Hamburg, discharge Antwerp, Belgium;
- Test cycle 3, uptake Felixstowe, discharge in the North Sea before entering the Elbe River; and
- Test cycle 4, uptake Hamburg, discharge Antwerp.

The holding time of the ballast water in the tank between uptake and discharge was between ca. 42 and 73 hours (Fig. 3).

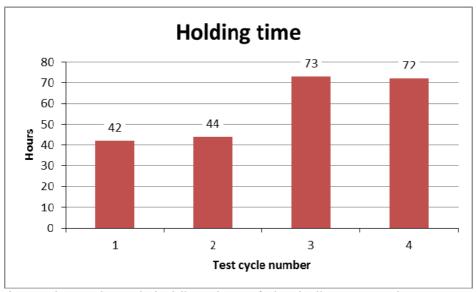


Figure 3. Approximate in-tank holding time of the ballast water between uptake and discharge during all test cycles.

During all test cycles all samples were taken by sampling team members of GoConsult, Hamburg, Germany, including additional samples required for WET tests and disinfection by-products analysis is full strength seawater as requested by BSH (UBA).

The chain of custody was guaranteed as the samples to be delivered to the land-based laboratories were transported by GoConsult staff so that no external manipulation was possible.

2. Sampling scenario

As shown in the on board sampling protocol (Gollasch 2012), multiple HydroBios ballast water sampling kits were used during each test cycle. For the discharge sampling event the ballast water samples were collected by using three sampling kits in parallel (Fig 4 & 5).



Figure 4. Sampling arrangements for ballast water uptake samples with Stephan Gollasch taking a phytoplankton sample.



Figure 5. Sampling arrangements for ballast water discharge samples with Matej David managing the sampling process.

The required number of samples and their volumes for one test cycle according to the IMO G8 Guidelines are given in Table 2.

Table 2. Number of samples and their volumes for one test cycle according to G8. The

paragraph numbers given refer to paragraphs of the IMO G8 Guidelines.

Sample	Treated tank	Control tank					
purpose	discharge	uptake	discharge				
	(para 2.2.2.6.2 and	(para 2.2.2.6.1,	(para 2.2.2.6.1 and				
	2.2.2.6.3)	2.2.2.6.3 and	2.2.2.6.3)				
	·	2.2.2.9)	·				
Environmental	1 sample	1 sample	1 sample				
parameters ³	(not required in G8)		(not required in G8)				
>50 µm ⁴	3 x >1000 L	1 x >1000 L	1 x >1000 L				
<50 to >10 µm	3 x >1 L	1 x >1 L	1 x >1 L				
Bacteriae	3 x >500 ml	1 x >500 ml	1 x >500 ml				
			(not required in G8)				

Sample processing was conducted on board as soon as possible after the sampling events were completed:

- Plankton organisms larger than 50 micron in minimum dimension were analysed directly after sampling.
- The sample processing of indicator microbes *E. coli* and *Enterococci* samples was also conducted directly after sampling and if needed the incubation time was completed on land either in a hotel room or at GoConsult.
- Cholera bacteria samples were prepared for later analysis by IBEN, Bremerhaven, Germany.
- The samples for
 - o total suspended solids (TSS).
 - o particulate organic carbon (POC),
 - $\circ~$ plankton less than 50 μm in minimum dimension and greater than or equal to 10 μm in minimum dimension, and
 - o the phytoplankton below 10 micron in minimum dimension

were prepared directly after sampling and the samples were stored in a fridge on board or with cooling elements in Styrofoam boxes during transport. The samples were analysed by NIOZ, Texel, the Netherlands as soon as possible after the voyage. Sample transport was arranged with the GoConsult courier.

³ Temperature, salinity, total suspended solids and particulate organic carbon, see G8, Annex, Part 2, paragraph 2.2.2.9

⁴ There is an inconsistency and unclear wording in G8 regarding the uptake sample of the treated line. G8, Annex, Part 2, paragraph 2.2.2.5 *Valid tests are indicated by uptake water, for both the control tank and ballast water to be treated, with viable organism concentration...* but 2.2.2.6 *Sampling regime* sets only requirements for the discharge of treated water. To be on the safe side samples during uptake of the treated water are therefore taken and processed.

Procedures for sample processing as outlined in the test protocol (Gollasch 2012) were followed. The protocol was prepared in line with the most up-to-date version of the IMO Guideline G8 *Guidelines for the Approval of Ballast Water Management Systems* (IMO G8, 2008).

The following samples were taken and processed in addition to the requirements of IMO Guideline G8:

- Analysis of environmental and biological parameters of the uptake <u>treated</u> water;
- Analysis of environmental parameters of the discharged treated water;
- Analysis of environmental parameters of the discharged control water;
- Analysis of bacteriae of the discharged control water; and
- Analysis of phytoplankton organisms below 10 micron in minimum dimension.

These additional samples were taken and processed to provide additional performance data of this treatment system.

3. Results

Results regarding environmental parameters and the biological analysis of the samples are shown in the following tables separately per each of all test cycles. As stated above more environmental parameters and more biological analysis than required by the IMO G8 Guidelines were conducted.

Environmental parameters

The results show values of environmental parameters as expected to occur in the ballast water uptake regions.

Biological results

The minimum intake concentrations of organisms for valid tests according to the IMO G8 Guidelines section 2.2.2.5 (challenge water) were met in all test cycles.

The results show that the water treated with the Siemens SeaCURE ballast water treatment system complied with the ballast water performance standards as provided in Regulation D-2 of the IMO Ballast Water Management Convention (IMO 2004). This applies at discharge of the treated ballast water for all test cycles and for all organism groups, including the phytoplankton organisms below 10 micron in minimum dimension.

Date and time for ballast water **uptake**: 22.10.2012, 19:52 to 20:33

Position of ship during start of ballast water uptake:

- in Port of Felixstowe.
- Water depth ca. 17 m.

Date and time for ballast water **discharge**: 24.10.2012, 14:12 to 15:42

Holding time of treated ballast water between uptake and discharge: approximately 42 hours.

Weather conditions during the test: good.

Table 3. Results of Test Cycle 1.

Paramatan	ĺ	Uptake water			Discharge water							
Parameter	Unit	control	IMO	before	Control	OMI	Treated			aver.	IMO	
		Control	IIVIO	treatment	Control	IIVIO	# 1	# 2	# 3	#1-#3	IIVIO	
Temperature	°C	12.9	-	13.0	14.0	-	13.7	13.7	13.7	-	-	
Salinity	psu	33.9	-	33.9	33.7	-	34.0	34.0	34.0	-	-	
POC *	mg/l	12.0	-	15.1	9.4	-	9.6	10.0	9.8	-	-	
TSS *	mg/l	49.7	-	44.3	21.4	-	23.0	25.4	23.4	-	-	
Sample vol. >50 µm	Litres	1066	>1000	1159	2773	>1000	3240	2979	2812	-	>1000	
Sample vol. 50-10 µm	Litres	7	>1	7	7	>1	7	7	7	-	>1	
Sample vol. Bacteria	Litres	1	>0,5	1	1	-	1	1	1	-	>0,5	
Organisms >50µm	org./1m³	1801	>90	3796	609	>10	1.2	6.5	2.7	3.5	<10	
Organisms 10-50µm*	org./1ml	578	>90	455	83	>10	nd	nd	nd	nd	<10	
Organisms 5-10µm*	org./1ml	78	ı	43	19	ı	nd	nd	nd	nd	-	
Escherichia coli	cfu/100ml	23	-	26	5	-	nd	nd	nd	nd	<250	
Intestinal Enterococci	cfu/100ml	60	-	120	80	-	nd	nd	nd	nd	<100	
Vibrio cholerae**	cfu/100ml	nd	-	nd	nd	-	nd	nd	nd	nd	<1	

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Date and time for ballast water **uptake**: 25.10.2012, 13:27 to 14:44

Position of ship during start of ballast water uptake:

- in Port of Hamburg.
- Water depth ca. 14.5 m.

Date and time for ballast water **discharge**: 27.10.2012, 09:05 to 10:34

Holding time of treated ballast water between uptake and discharge approximately 44 hours.

Weather conditions during the test: good, light vessel rolling.

Table 4. Results of Test Cycle 2.

Paramatan	ĺ	U	ptake wa	Discharge water							
Parameter	Unit	control	IMO	before	Control	IMO	Treated			aver.	IMO
		Control	IIVIO	treatment	Control	IIVIO	# 1	# 2	# 3	#1-#3	IIVIO
Temperature	°C	12.5	-	12.5	13.4	-	13.3	13.3	13.3	-	-
Salinity	Psu	0.4	-	0.4	1.2	-	2.6	2.6	2.6	-	-
POC *	mg/l	14.0	-	11.6	4.2	-	4.8	4.6	4.8	-	-
TSS *	mg/l	36.0	-	30.0	16.6	-	8.0	8.6	8.2	-	-
Sample vol. >50 µm	Litres	1979	>1000	1388	2051	>1000	2442	2502	2522	-	>1000
Sample vol. 50-10 µm	Litres	7	>1	5	7	>1	7	7	7	-	>1
Sample vol. bacteria	Litres	1	>0,5	1	1	-	1	1	1	-	>0,5
Organisms >50µm	org./1m³	7369	>90	17231	7574	>10	9.5	9.2	7.6	8.8	<10
Organisms 10-50µm*	org./1ml	4728	>90	5798	1346	>10	nd	nd	nd	nd	<10
Organisms 5-10µm*	org./1ml	315	-	525	231	-	nd	nd	nd	nd	-
Escherichia coli	cfu/100ml	180	-	110	30	-	nd	nd	nd	nd	<250
Intestinal Enterococci	cfu/100ml	nd	-	nd	60	-	10	30	20	20	<100
Vibrio cholerae**	cfu/100ml	nd	-	nd	nd	-	nd	nd	nd	nd	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Date and time for ballast water <u>uptake</u>: 21.05.2013, 15:56 to 16:46

Position of ship during ballast water uptake:

- in Port of Felixstowe.
- Water depth ca. 17 m.

Date and time for ballast water **discharge**: 24.05.2013, 18:11 to 18:58

Holding time of treated ballast water between uptake and discharge approximately 73 hours.

Table 5. Results of Test Cycle 3.

Danas atau	1111	Uptake water			Discharge water							
Parameter	Unit	control	IMO	before	Control	OMI	Treated			aver.	IMO	
		COILLIOI	IIVIO	treatment	Control	IIVIO	# 1	# 2	# 3	#1-#3	IIVIO	
Temperature	°C	12.5	-	12.6	10.8	-	10.8	10.8	10.8	-	-	
Salinity	Psu	32.8	-	32.9	33.0	-	32.8	32.8	32.8	-	-	
POC *	mg/l	15.2	-	9.3	8.6	-	9.6	10.0	9.6	-	-	
TSS *	mg/l	41.6	-	24.2	21.4	-	20.6	22.4	23.6	-	-	
Sample vol. >50 µm	Litres	1179	>1000	1271	1420	>1000	1669	1604	1624	-	>1000	
Sample vol. 50-10 µm	Litres	7	>1	7	7	>1	7	7	7	-	>1	
Sample vol. Bacteria	Litres	1	>0,5	1	1	-	1	1	1	-	>0,5	
Organisms >50µm	org./1m³	4597	>90	7553		>10	2.3	7.2	4.7	4.7	<10	
Organisms 10-50µm*	org./1ml	122	>90	58	48	>10	nd	nd	nd	nd	<10	
Organisms 5-10µm*	org./1ml	1448	-	531	571	-	nd	nd	nd	nd	-	
Escherichia coli	cfu/100ml	140	-	80	11	-	nd	nd	nd	nd	<250	
Intestinal Enterococci	cfu/100ml	320	-	340	130	-	nd	nd	nd	nd	<100	
Vibrio cholerae**	cfu/100ml	nd	-	nd	nd	-	nd	nd	nd	nd	<1	

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Date and time for ballast water <u>uptake</u>: 26.05.2013, 13:44 to 14:56

Position of ship during ballast water uptake:

- in Port of Hamburg.
- Water depth ca. 14.5 m.

Date and time for ballast water **discharge**: 29.05.2013, 16:30 to 17:46

Holding time of treated ballast water between uptake and discharge approximately 72 hours.

Table 6. Results of Test Cycle 4.

Paramatan	11	Uptake water			Discharge water							
Parameter	Unit	control	IMO	before	Control	IMO	Treated			aver.	IMO	
		COILLIOI	IIVIO	treatment	Control	IIVIO	# 1	# 2	# 3	#1-#3	IIVIO	
Temperature	°C	14.6	-	15.3	12.9	-	12.7	12.7	12.7	-	-	
Salinity	Psu	0.3	-	0.8	1.0	-	2.2	2.2	2.2	-	-	
POC *	mg/l	17.6	-	9.0	8.9	-	6.2	5.0	4.8	-	-	
TSS *	mg/l	50.0	-	21.3	12.3	-	9.8	7.6	7.8	-	-	
Sample vol. >50 µm	Litres	1314	>1000	1618	1196	>1000	1652	1660	1625	-	>1000	
Sample vol. 50-10 µm	Litres	7	>1	7	7	>1	7	7	7	-	>1	
Sample vol. Bacteria	Litres	1	>0,5	1	1	-	1	1	1	-	>0,5	
Organisms >50µm	org./1m³	32116	>90	28059	5658	>10	7.0	7.0	4.7	6.2	<10	
Organisms 10-50µm*	org./1ml	5311	>90	1240	1364	>10	nd	nd	nd	nd	<10	
Organisms 5-10µm*	org./1ml	2417	ı	1585	2147	ı	nd	nd	nd	nd	ı	
Escherichia coli	cfu/100ml	80	-	240	60	-	20	20	nd	13.3	<250	
Intestinal Enterococci	cfu/100ml	110	-	160	90	-	50	10	30	30.0	<100	
Vibrio cholerae**	cfu/100ml	nd	-	nd	nd	-	nd	nd	nd	nd	<1	

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

4. Discussion of the results

The Siemens SeaCURE ballast water treatment system was intensively tested during the two test voyages on which four test cycles were undertaken in total (October 2012 and May 2013). The tests were conducted in different environmental water conditions (including fully marine and freshwater conditions) and different seasons resulting in higher and lower organism concentrations in the uptake water. During these tests the system has proven to be very effective to treat organisms in ballast water.

During all on board tests, sample taking, sample processing and sample forwarding was always conducted as outlined in the agreed sampling protocol (Gollasch 2012).

The treated water at discharge of all test cycles met the Ballast Water Performance Standard as shown in Regulation D-2 of the IMO Ballast Water Management Convention (IMO 2004).

Although this report primarily focuses on the organism groups addressed in Regulation D-2, in addition the phytoplankton organisms in the size class below 10 micron in minimum dimension were measured and no living phytoplankton in this category was observed in the treated water at discharge.

5. Test validity

Samples

All required samples were taken to document the abiotic and biotic water conditions during the tests. In exceedence of IMO G8 requirements, additional samples were taken and all samples were analysed for more parameters as required by this guideline. The minimum water volumes of all sample types, as stated in the IMO G8 Guidelines, were met during all tests.

Biology

The minimum organism intake concentrations to challenge the treatment system exceeded the required numbers as stated in the IMO G8 Guidelines in all test cycles.

The organism discharge standards as stated in Regulation D-2 of the IMO Ballast Water Management Convention of 2004 was met at discharge of the treated water in all test cycles.

Consequently, all four tests may be considered as valid tests according to the IMO requirements (Guidelines G8 and Regulation D-2).

References

Gollasch, S. 2012. Quality Management Plan and Quality Assurance Project Plan for Shipboard Tests of the SiCURE Ballast Water Treatment System developed by Siemens. Version VIII, 2012-09-12, 51 pp.

IMO 2004. International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004. International Maritime Organization, 13 February 2004. 36 pp.

IMO G8 2008. IMO Guideline G8 Guidelines for the Approval of Ballast Water Management Systems adopted on 10 October 2008 as Resolution MEPC.174(58), 28 pp.

Appendix 1 Statement regarding ship-board tests

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Statement regarding Shipboard-Tests of the Siemens Water Technologies LLC (USA) SeaCURE Ballast Water Management System

04-06-2013

To whom it may concern

This is to confirm that the shipboard tests of the SeaCURE ballast water treatment system, developed by Siemens Water Technologies LLC, Union, NJ 07083, USA, as documented in

Final Report, Shipboard Tests of the SiCURE⁵ (Siemens) Ballast Water Treatment System (filtration and electrochlorination) for Type Approval according to Regulation D-2 and the relevant IMO Guideline (G8) [the document this statement is appended to]

were undertaken according to

Gollasch, S. 2012. Quality Management Plan and Quality Assurance Project Plan for Shipboard Tests of the SiCURE Ballast Water Treatment System developed by Siemens. Version VIII, 2012-09-12, 51 pp.

which was evaluated and approved by the Bundesamt für Seeschifffahrt und Hydrographie (BSH), Hamburg prior to the tests. The GoConsult on board work was observed by BSH experts during a vessel visit in the Port of Hamburg.

Kind regards,

S. Gollasch

Principal investigator, GoConsult

 $^{^{\}mbox{\scriptsize 5}}$ Please note that the name oft he treatment system was changed from SiCURE to now SeaCURE.